APPENDIX
MEASUREMENT OF RADAR SPURIOUS EMISSIONS AND APPLICATION OF THE RSEC

A.1 MEASUREMENT OF RADAR SPURIOUS EMISSIONS

This appendix outlines procedures for the measurement of radar spurious emissions. Such measurements can be used to determine compliance of the radar with the RSEC (see Section 2). Such a measurement may require the resources of a frequency management agency. The measurement may be used to determine the radar's compliance with the RSEC or other applicable emission criteria. Measurement of the extended radar spectrum will indicate the power density at the frequency of the earth station, and hence the likelihood that sufficient power exists at the earth station's frequency and in the earth station's bandwidth to cause in-band interference.

A broadband radar emission spectrum will typically have to be measured across a frequency range of at least 1 GHz, and possibly much more. The dynamic range required of the measurement system will typically be at least 100 dB, so that both the power at the center frequency of the radar and in the spurious emission spectrum can be observed. To achieve this dynamic range, a variable RF attenuator should be installed at the front-end of the measurement system. If, for example, the attenuator is 0-70 dB and the measurement system has an instantaneous dynamic range of at least 50 dB, then 120 dB of total dynamic range can be achieved.

It is important that the measurement system not experience front-end overload while the measurement is in progress. Therefore, tunable front-end preselection is required. Current technology provides yttrium-iron-garnet (YIG) preselectors which can be used for this function in the range of 500 MHz to 18 GHz. Varactor preselection may be used below 500 MHz.

High sensitivity is required for the portion of the measurement that includes the spurious emissions in the extended radar spectrum. Low-noise amplifiers following the preselector can compensate for line loss and other components of measurement system noise figure. The NTIA Radio Spectrum Measurement System (RSMS), shown as a block diagram in Figure A-1, incorporates all of the features described here: Variable RF attenuation for wide dynamic range, automatic tracking preselection to prevent front-end overload from strong out-of-band signals, and low-noise preamplification to provide maximum measurement system sensitivity. A subset of the equipment shown in Figure A-1, called the Component Radio Spectrum Measurement System (CRSMS), can also be used for measurements of radar spurious emissions, and incorporates the same features of wide dynamic range, preselection, and sensitivity.

The most efficient way to measure an extended radar emission spectrum is stepping across the spectrum in the frequency domain rather than sweeping across in the more conventional manner. Stepping means tuning the measurement system to a single frequency in a measurement (IF) bandwidth and using a fast-running positive peak detector to capture the highest emission received from the radar at that frequency during one full rotation of the radar beam. (Video bandwidth, which is post-detected lowpass filtering, should be as wide or wider than the measurement bandwidth.) That highest emission received during the radar rotation is then retrieved by a controller computer, corrected for calibration factors, and stored

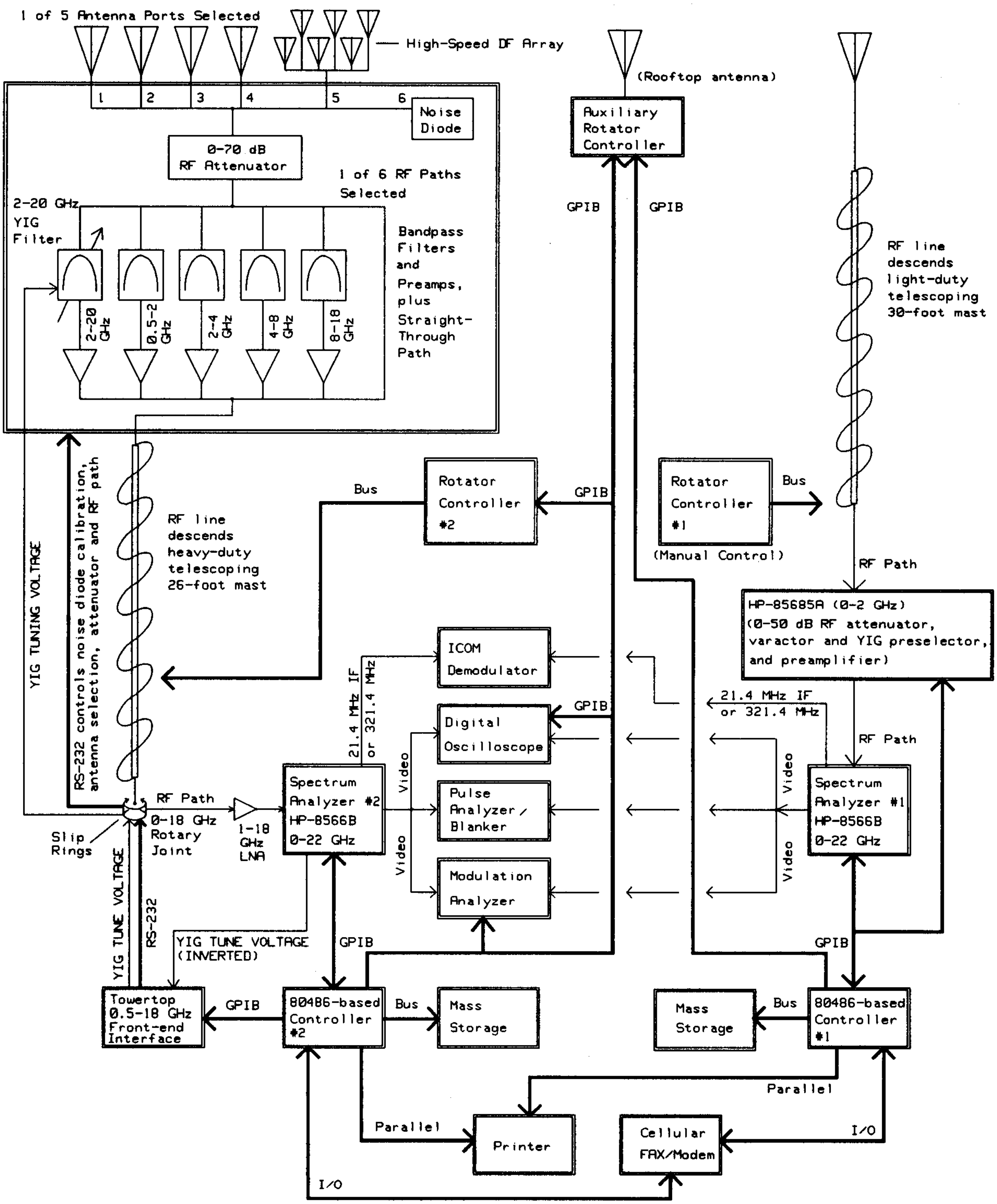

Figure A-1. Block diagram of the NTIA/ITS Radio Spectrum Measurement System (RSMS). The RSMS is a Department of Commerce asset used to assess and resolve radio spectrum occupancy questions and problems.

in memory. Then, the measurement system is tuned in frequency by an amount approximately equal to the measurement bandwidth (e.g., the measurement frequency is tuned 1 MHz higher if the measurement bandwidth is 1 MHz), and the process is repeated for the new frequency during the next rotation of the radar. Thus, one measured frequency step occurs with each rotation of the radar. The stepping process is continued until the entire measurable spectrum has been acquired. All radar spectra presented in this report (e.g., Figures 13-1 5) were made using the stepped technique. The stepped technique has several advantages over the conventional swept technique for spurious radar emission measurements:

1) Stepping is at least twice as fast at filling in the spectrum as sweeping in a maximum hold mode

2) Stepping allows for greater dynamic range than sweeping, because attenuation can be increased and decreased as a function of measurement frequency and as required by the rise and fall of the measured spectrum across that frequency range

3) Stepping creates a deterministic, rather than a probabilistic, spectral envelope. That is, a dip in a swept spectrum may be the result of not having sampled adequately at those frequencies where the dip occurred, and verification of whether or not the dip is real is difficult, whereas a dip in a stepped spectrum measurement must represent a real dip in the emission spectrum.

A.2 APPLICATION OF THE RSEC

Application of the RSEC to the measured spectrum of a radar is complicated by the fact that the measured peak power of the spurious emissions relative to the measured peak power of the radar fundamental frequency may be dependent upon the selection of the measurement (IF) bandwidth. Such dependence will occur if the measurement is peak-detected and utilizes a video bandwidth (post-detected low-pass filtering) which is as wide as or wider than the IF bandwidth, as is usually true for radar spectrum measurements. Such a case is shown in Figure A-2.

In Figure A-2, the radar spectrum has been measured in IF bandwidths of 300 kHz and 1 MHz. While the center frequency power levels are unchanged when measured in these two bandwidths, the spurious emission levels change by anywhere from 5 to 15 dB, with a typical difference of about 10 dB. This 10 dB difference is consistent with the theoretically expected change of 20 log(measurement bandwidth ratio). (In this example, 20 log(1 MHz/300 kHz) = 10.5 dB expected difference between the two spurious emission measurements.)

This phenomenon (a bandwidth-independent power measurement at center frequency with a bandwidth-dependent power measurement in the spurious emission spectrum) will occur in peak-detected measurements utilizing wide video bandwidths and measurement (IF) bandwidths which are wider than approximately (1 /radar pulse width). If the measurement bandwidths are equal to or less than (1 /radar pulse width), then the power measurement at the center frequency will also be bandwidth-dependent and will go as 20 log(measurement bandwidth ratio), and the ratio between power levels at the center frequency and in the

spurious emissions will be constant. Table A-1 summarizes the relationship between the measurement bandwidth, the radar pulse width, and the correction which NTIA applies to measured radar emission spectra.

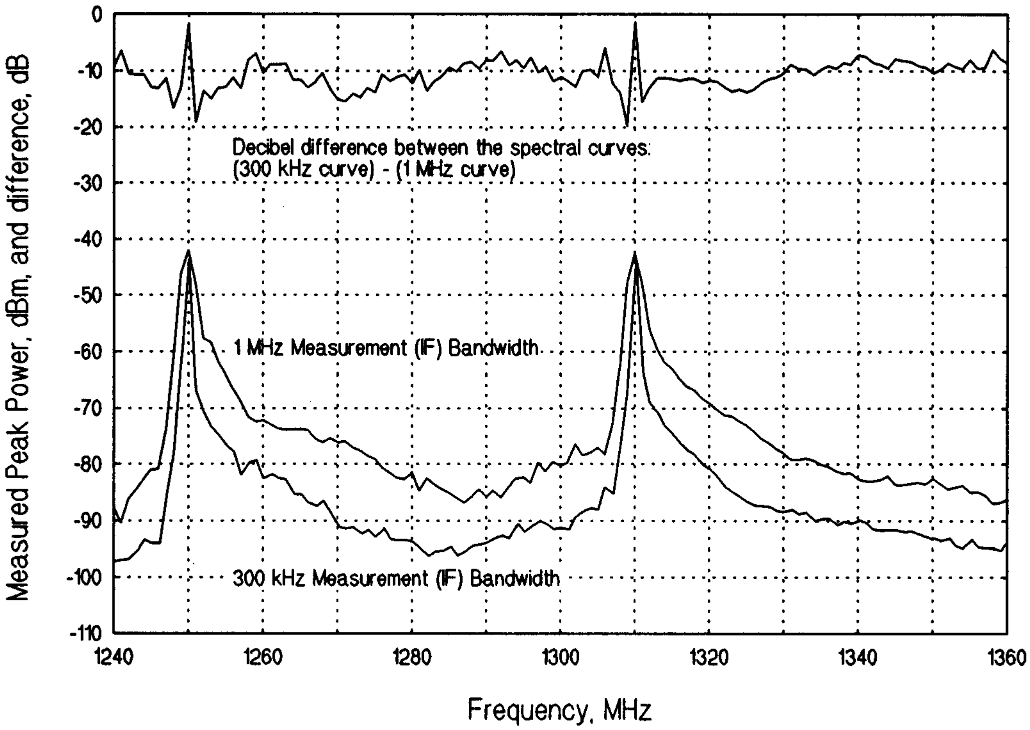

Figure A-2. **Measured emission spectra of a radar in two different measurement bandwidths. The center frequency power level does not change, but the spurious emissions change by about 20 log(bandwidth ratio) = 10 dB.**

TABLE A-1 .
RELATION BETWEEN MEASUREMENT BANDWIDTH, RADAR PULSE WIDTH AND NTIA CORRECTION FOR WIDE-BANDWIDTH MEASUREMENTS*

Width of Measurement (IF) Bandwidth Relative to Radar Pulse Width	NTIA Correction for Application of the RSEC
Measurement Bandwidth > (1/radar pulse width)	Correct either by graphically/numerically reducing the measured spurious emission levels or by raising the RSEC envelope. Correction value is 20 log(measurement bandwidth/radar pulse width)
Measurement Bandwidth ≤ (1/radar pulse width)	No correction necessary.

*** These corrections are appropriate for cases in which the measurement is performed using peak detection and a video bandwidth (post-detected lowpass filtering) which is as wide or wider than the measurement (IF) bandwidth.**